AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A method for enhancing the resolution of an image sensing device, comprising the steps of:

~~attaching a mask to a panel of detectors in an image sensing device;~~

~~generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;~~

~~acquiring multiple images with the image sensing device from the multiple fields of view; and~~

applying a periodically patterned mask to an image sensing device having a pixel sensitivity function, the device comprising a periodic array of detectors having at least one of a horizontal periodic spacing and a vertical periodic spacing,

the periodically patterned mask having at least one of a horizontal period which is an integer multiple of said detectors' horizontal periodic spacing and a vertical period which is an integer multiple of the detectors' vertical periodic spacing,

the mask modifying the pixel sensitivity function of the image sensing device, thereby to define a modified pixel sensitivity function of the device whose Fourier transform does not have zeros at frequencies that are between 0 and the maximal frequency at which no significant aliasing occurs;

using the image sensing device with the mask to acquire multiple images of a scene from corresponding multiple fields of view related to one another by sub-pixel shifts, the multiple images defining sub-pixel samples; and

combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images, including:

computing a Fourier transform of said samples;

dividing said Fourier transform of said samples by a Fourier transform of said modified pixel sensitivity function, thereby to define a quotient; and

computing an inverse Fourier transform of the quotient, thereby to define the enhanced image.

2. (Original) The method of claim 1 wherein the image sensing device is a scanner.

3. (Original) The method of claim 2 wherein the image sensing device is a barcode reader.

4. (Original) The method of claim 1 wherein the image sensing device is a CCD camera.

5. (Original) The method of claim 1 wherein the mask is a fine transmission grating.

6. (Currently Amended) ~~The method of claim 5 wherein~~ A method for enhancing the resolution of an image sensing device, comprising the steps of:

attaching a mask to a panel of detectors in an image sensing device, the mask being a fine transmission grating, the panel of detectors ~~comprises~~ comprising a periodic array of detectors, and the mask ~~is~~ being periodic with period equal to that of the periodic array of detectors;

generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;

acquiring multiple images with the image sensing device from the multiple fields of view; and

combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images.

7. (Currently Amended) ~~The method of claim 5 wherein~~ A method for enhancing the resolution of an image sensing device, comprising the steps of:

attaching a mask to a panel of detectors in an image sensing device, the mask being a fine transmission grating, the panel of detectors ~~comprises~~ comprising a periodic array of detectors, and the mask ~~is~~ being periodic with period twice that of the periodic array of detectors;

generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;

acquiring multiple images with the image sensing device from the multiple fields of view; and

combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images.

8. (Currently Amended) ~~The method of claim 5 further comprising the step of~~ A method for enhancing the resolution of an image sensing device, comprising the steps of:

attaching a mask to a panel of detectors in an image sensing device, the mask being a fine transmission grating;

generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;

acquiring multiple images with the image sensing device from the multiple fields of view;

combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images, and

determining the number of slits, the positions of the slits and the widths of the slits in the fine transmission grating.

9. (Original) The method of claim 8 wherein said determining step determines the number of slits, the positions of the slits and the widths of the slits, so that the mask eliminates zeroes in a Fourier transform of a function representing a sensitivity of a pixel, within a prescribed range of frequencies.

10. (Original) The method of claim 9 wherein the widths of the slits are constrained so as not to block more than a prescribed fraction of light energy from reaching the detectors.

11. (Original) The method of claim 9 wherein the widths of the slits are constrained so as not to be smaller than a prescribed minimum width.

12. (Original) The method of claim 9 wherein said determining step uses a weight function specifying relative weights to be placed on values for the widths of the slits.

13. (Original) The method of claim 9 wherein the mask is of the form

$$m(x) = 1 - \sum_{i=1}^{M} rect(\frac{x}{\delta x_i}) \otimes \delta(x - x_i) \ .$$

14. (Currently Amended) A method for enhancing the resolution of an image sensing device, comprising the steps of:

attaching a mask to a panel of detectors in an image sensing device;

generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;

acquiring multiple images with the image sensing device from the multiple fields of view; and

combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images,

~~The method of claim 1~~ wherein said generating step uses natural vibrations of a platform supporting the sensing device.

15. (Currently Amended) A method for enhancing the resolution of an image sensing device, comprising the steps of:

attaching a mask to a panel of detectors in an image sensing device;

generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;

acquiring multiple images with the image sensing device from the multiple fields of view; and

combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images,

~~The method of claim 1~~ wherein said generating step uses at least one mirror to shift fields of view of the image sensing device by sub-pixel shifts.

16. (Currently Amended) A method for enhancing the resolution of an image sensing device, comprising the steps of:

attaching a mask to a panel of detectors in an image sensing device;

generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;

acquiring multiple images with the image sensing device from the multiple fields of view; and

combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images,

~~The method of claim 1~~ wherein said combining step is applied separately to rows and columns of pixel data.

17. (Original) The method of claim 16 wherein said combining step uses the approximation

$$U(e^{j\omega}) \approx \frac{Y(e^{j\omega})}{G(-j\frac{\omega K}{\Delta x})},$$

to determine the rows and columns of pixel data of the enhanced image.

18. (Original) The method of claim 17 wherein said combining step comprises applying an inverse Fourier transform to values of $U(e^{j\omega})$.

19. (Original) The method of claim 16 wherein said combining step uses the approximation

$$U(e^{j\omega}) \approx \frac{1}{2}\left[Y(e^{j\frac{\omega}{2}})/G(-j\frac{\omega K}{\Delta x}) + Y(e^{j\frac{\omega-2\pi}{2}})/G(-j\frac{(\omega-2\pi)K}{\Delta x})\right],$$

$$0 < \omega < \pi,$$

for positive values of ω, and

$$U(e^{j\omega}) \approx \frac{1}{2}\left[Y(e^{j\frac{\omega}{2}})/G(-j\frac{\omega K}{\Delta x}) + Y(e^{j\frac{\omega+2\pi}{2}})/G(-j\frac{(\omega+2\pi)K}{\Delta x})\right]$$

$$-\pi < \omega < 0,$$

for negative values of ω, to determine the rows and columns of pixel data of the enhanced image.

20. (Original) The method of claim 19 wherein said combining step comprises applying an inverse Fourier transform to values of $U(e^{j\omega})$.

21. (Original) The method of claim 16 wherein said combining step uses the approximation

$$U(e^{j\omega}) \approx \left[Y_2(e^{j\omega})\delta_{\frac{2\pi K}{\Delta x}} G_1(-j\frac{\omega K}{\Delta x}) - Y_1(e^{j\omega})\delta_{\frac{2\pi K}{\Delta x}} G_2(-j\frac{\omega K}{\Delta x}) \right] \Bigg/$$

$$\left[G_2(-j\frac{\omega K}{\Delta x})\delta_{\frac{2\pi K}{\Delta x}} G_1(-j\frac{\omega K}{\Delta x}) - G_1(-j\frac{\omega K}{\Delta x})\delta_{\frac{2\pi K}{\Delta x}} G_2(-j\frac{\omega K}{\Delta x}) \right]$$

for positive values of ω, $0 < \omega < \pi$, and

$$U(e^{j\omega}) \approx \left[Y_2(e^{j\omega})\delta_{-\frac{2\pi K}{\Delta x}} G_1(-j\frac{\omega K}{\Delta x}) - Y_1(e^{j\omega})\delta_{-\frac{2\pi K}{\Delta x}} G_2(-j\frac{\omega K}{\Delta x}) \right] \Bigg/$$

$$\left[G_2(-j\frac{\omega K}{\Delta x})\delta_{-\frac{2\pi K}{\Delta x}} G_1(-j\frac{\omega K}{\Delta x}) - G_1(-j\frac{\omega K}{\Delta x})\delta_{-\frac{2\pi K}{\Delta x}} G_2(-j\frac{\omega K}{\Delta x}) \right]$$

for negative values of ω, $-\pi < \omega < 0$, and wherein the terms $\delta_\Psi G(-j\Omega)$ denote the difference

$$\delta_\Psi G(-j\Omega) = G(-j\Omega) - G(-j(\Omega - \Psi)),$$

to determine the rows and columns of pixel data of the enhanced image.

22. (Original) The method of claim 21 wherein said combining step comprises applying an inverse Fourier transform to values of $U(e^{j\omega})$.

23. (Original) The method of claim 1 wherein said combining step uses a Gabor transform.

24. (Original) The method of claim 1 wherein said combining step uses a wavelet transform.

25. (Original) The method of claim 1 wherein said combining step uses a Mellin transform.

26. (Currently Amended) A system for enhancing the resolution of an image sensing device, comprising:

an image sensing device comprising ~~a panel~~ a periodic array of detectors having at least one of a horizontal periodic spacing and a vertical periodic spacing, said image sensing device having a pixel sensitivity function;

a periodically patterned mask attached to said image sensing device, said mask having at least one of a horizontal period which is an integer multiple of said detectors' horizontal periodic spacing and a vertical period which is an integer multiple of the detectors' vertical periodic spacing, said mask being operative to modify said pixel sensitivity function of said image sensing device, thereby to define a modified pixel sensitivity function of said device whose Fourier transform does not have zeros at frequencies that are between 0 and the maximal frequency at which no significant aliasing occurs;

image acquisition circuitry, operative to acquire multiple images of a scene from corresponding multiple fields of view related to one another by sub-pixel shifts, said multiple images defining sub-pixel samples; and

~~a mask attached to said panel of detectors;~~

~~a motion generator generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;~~

~~image acquisition circuitry housed within said image sensing device acquiring multiple images from the multiple fields of view; and~~

a combiner combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images, said combiner being operative

to compute a Fourier transform of said samples;

to divide said Fourier transform of said samples by a Fourier transform of said modified pixel sensitivity function, thereby to define a quotient; and

to compute an inverse Fourier transform of the quotient, thereby to define the enhanced image.

27. (Original) The system of claim 26 wherein said image sensing device is a scanner.

28. (Original) The system of claim 27 wherein said image sensing device is a barcode reader.

29. (Original) The system of claim 26 wherein said image sensing device is a CCD camera.

30. (Original) The system of claim 26 wherein said mask is a fine transmission grating.

31. (Currently Amended) ~~The system of claim 30 wherein~~ A system for enhancing the resolution of an image sensing device, comprising:

an image sensing device comprising a panel of detectors, said panel of detectors ~~comprises~~ comprising a periodic array of detectors;

a mask attached to said panel of detectors, said mask being a fine transmission grating, and said mask ~~is~~ being periodic with period equal to that of said periodic array of detectors;

a motion generator generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;

image acquisition circuitry housed within said image sensing device acquiring multiple images from the multiple fields of view; and

a combiner combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images.

32. (Currently Amended) ~~The system of claim 30 wherein~~ A system for enhancing the resolution of an image sensing device, comprising:

an image sensing device comprising a panel of detectors, said panel of detectors ~~comprises~~ comprising a periodic array of detectors;

a mask attached to said panel of detectors, said mask being a fine transmission grating, and said mask ~~is~~ being periodic with period twice that of said periodic array of detectors;

a motion generator generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;

image acquisition circuitry housed within said image sensing device acquiring multiple images from the multiple fields of view; and

a combiner combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images.

33. (Currently Amended) ~~The system of claim 30 further comprising~~ A system for enhancing the resolution of an image sensing device, comprising:

an image sensing device comprising a panel of detectors;

a mask attached to said panel of detectors, said mask being a fine transmission grating;

a motion generator generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;

image acquisition circuitry housed within said image sensing device acquiring multiple images from the multiple fields of view;

a combiner combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images; and

a grating generator determining the number of slits, the positions of the slits and the widths of the slits in the fine transmission grating.

34. (Original) The system of claim 33 wherein said grating generator determines the number of slits, the positions of the slits and the widths of the slits, so that said mask eliminates zeroes in a Fourier transform of a function representing a sensitivity of a pixel.

35. (Original) The system of claim 34 wherein the widths of the slits are constrained so as not to block more than a prescribed fraction of light energy from reaching the detectors.

36. (Original) The system of claim 34 wherein the widths of the slits are constrained so as not to be smaller than a prescribed minimum width.

37. (Original) The system of claim 34 wherein said grating generator uses a weight function specifying relative weights to be placed on values for the widths of the slits.

38. (Original) The system of claim 34 wherein said mask is of the form

$$m(x) = 1 - \sum_{i=1}^{M} rect(\frac{x}{\delta x_i}) \otimes \delta(x - x_i).$$

39. (Currently Amended) ~~The system of claim 26 wherein~~ A system for enhancing the resolution of an image sensing device, comprising:

an image sensing device comprising a panel of detectors;

a mask attached to said panel of detectors;

a motion generator generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts, said motion generator ~~uses~~ using natural vibrations of a platform supporting the sensing device;

image acquisition circuitry housed within said image sensing device acquiring multiple images from the multiple fields of view; and

a combiner combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images.

40. (Currently Amended) ~~The system of claim 26 wherein~~ A system for enhancing the resolution of an image sensing device, comprising:

an image sensing device comprising a panel of detectors;

a mask attached to said panel of detectors;

a motion generator generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts, said motion generator ~~uses~~ using at least one mirror to shift fields of view of the image sensing device by sub-pixel shifts;

image acquisition circuitry housed within said image sensing device acquiring multiple images from the multiple fields of view; and

a combiner combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images.

41. (Currently Amended) ~~The system of claim 26 wherein~~ A system for enhancing the resolution of an image sensing device, comprising:

an image sensing device comprising a panel of detectors;

a mask attached to said panel of detectors;

a motion generator generating multiple fields of view, the multiple fields of view being related to one another by sub-pixel shifts;

image acquisition circuitry housed within said image sensing device acquiring multiple images from the multiple fields of view; and

a combiner combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images, said combiner ~~is~~ being applied separately to rows and columns of pixel data.

42. (Original) The system of claim 41 wherein said combiner uses the approximation

$$U(e^{j\omega}) \approx \frac{Y(e^{j\omega})}{G(-j\frac{\omega K}{\Delta x})},$$

to determine the rows and columns of pixel data of the enhanced image.

43. (Original) The system of claim 42 wherein said combiner applies an inverse Fourier transform to values of $U(e^{j\omega})$.

44. (Original) The system of claim 41 wherein said combiner uses the approximation

$$U(e^{j\omega}) \approx \frac{1}{2}\left[Y(e^{j\frac{\omega}{2}})/G(-j\frac{\omega K}{\Delta x}) + Y(e^{j\frac{\omega-2\pi}{2}})/G(-j\frac{(\omega-2\pi)K}{\Delta x})\right],$$

$$0 < \omega < \pi\ ,$$

for positive values of ω, and

$$U(e^{j\omega}) \approx \frac{1}{2}\left[Y(e^{j\frac{\omega}{2}})/G(-j\frac{\omega K}{\Delta x}) + Y(e^{j\frac{\omega+2\pi}{2}})/G(-j\frac{(\omega+2\pi)K}{\Delta x})\right]$$

$$-\pi < \omega < 0\ ,$$

for negative values of ω, to determine the rows and columns of pixel data of the enhanced image.

45. (Original) The system of claim 44 wherein said combiner comprises applying an inverse Fourier transform to values of $U(e^{j\omega})$.

46. (Original) The system of claim 41 wherein said combiner uses the approximation

$$U(e^{j\omega}) \approx \left[Y_2(e^{j\omega})\delta_{\frac{2\pi K}{\Delta x}} G_1(-j\frac{\omega K}{\Delta x}) - Y_1(e^{j\omega})\delta_{\frac{2\pi K}{\Delta x}} G_2(-j\frac{\omega K}{\Delta x}) \right] \Big/$$

$$\left[G_2(-j\frac{\omega K}{\Delta x})\delta_{\frac{2\pi K}{\Delta x}} G_1(-j\frac{\omega K}{\Delta x}) - G_1(-j\frac{\omega K}{\Delta x})\delta_{\frac{2\pi K}{\Delta x}} G_2(-j\frac{\omega K}{\Delta x}) \right]$$

for positive values of ω, $0 < \omega < \pi$, and

$$U(e^{j\omega}) \approx \left[Y_2(e^{j\omega})\delta_{-\frac{2\pi K}{\Delta x}} G_1(-j\frac{\omega K}{\Delta x}) - Y_1(e^{j\omega})\delta_{-\frac{2\pi K}{\Delta x}} G_2(-j\frac{\omega K}{\Delta x}) \right] \Big/$$

$$\left[G_2(-j\frac{\omega K}{\Delta x})\delta_{-\frac{2\pi K}{\Delta x}} G_1(-j\frac{\omega K}{\Delta x}) - G_1(-j\frac{\omega K}{\Delta x})\delta_{-\frac{2\pi K}{\Delta x}} G_2(-j\frac{\omega K}{\Delta x}) \right]$$

for negative values of ω, $-\pi < \omega < 0$, and wherein the terms $\delta_\Psi G(-j\Omega)$ denote the difference

$$\delta_\Psi G(-j\Omega) = G(-j\Omega) - G(-j(\Omega-\Psi)),$$

to determine the rows and columns of pixel data of the enhanced image.

47. (Original) The system of claim 46 wherein said combiner comprises applying an inverse Fourier transform to values of $U(e^{j\omega})$.

48. (Original) The system of claim 26 wherein said combiner uses a Gabor transform.

49. (Original) The system of claim 26 wherein said combiner uses a wavelet transform.

50. (Original) The system of claim 26 wherein said combiner uses a Mellin transform.

51. (Currently Amended) A method ~~for enhancing the resolution of an image sensing device~~ according to claim 1, comprising the steps of:

creating replicas of fields of view using an optical element attached to ~~an image~~ the image sensing device;

acquiring multiple images with the sensing device from the replicas of fields of view; and

combining the multiple images acquired from the replicas into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images acquired from the replicas.

52. (Original) The method of claim 51 wherein the optical element is a diffractive optical element.

53. (Original) The method of claim 51 wherein the optical element is a reflective optical element.

54. (Original) The method of claim 51 wherein the optical element is a combined diffractive and reflective optical element.

55. (Original) The method of claim 51 wherein the optical element produces an effect of a grating.

56. (Original) The method of claim 51 wherein the optical element is multi-faceted.

57. (Original) The method of claim 51 wherein the replicas of fields of views are non-overlapping.

58. (Currently Amended) A system ~~for enhancing the resolution of an image sensing device, comprising:~~

~~an image sensing device;~~

~~an optical element attached to said image sensing device, said optical element being such as to create replicas of fields of view;~~

~~image acquisition circuitry housed within said image sensing device acquiring multiple images from the replicas of fields of view; and~~

~~a combiner combining the multiple images into an enhanced image of higher pixel resolution than the pixel resolutions of the multiple images.~~

according to claim 26 wherein said multiple images are acquired by creating replicas of fields of view using an optical element attached to the image sensing device.

59. (Original) The system of claim 58 wherein said optical element is a diffractive optical element.

60. (Original) The system of claim 58 wherein said optical element is a reflective optical element.

61. (Original) The system of claim 58 wherein said optical element is a combined diffractive and reflective optical element.

62. (Original) The system of claim 58 wherein said optical element produces an effect of a grating.

63. (Original) The system of claim 58 wherein said optical element is multi-faceted.

64. (Original) The system of claim 58 wherein the replicas of fields of view are non-overlapping.

65. (New) A method according to claim 1 wherein said applying of a mask comprises bringing the mask into a substantially touching engagement with a detector plane defined by the periodic array of detectors.